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EVALUATION OF FINE DENIER AND MICRODENIER MULTIFILAMENT FABRICS

by

C. Winterhalter

February 2002

Final Report
January 1991 - December 1994

Approved for Public Release; Distribution is Unlimited

U.S. Army Soldier and Biological Chemical Command
Soldier Systems Center
Natick, Massachusetts 01760-5019

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The objective of this program is to investigate commercially available fabrics that are lightweight and offer equal or improved water repellency, greater durability, and are quick to dry compared to MIL-C-3924, Cloth, Oxford, Cotton Warp and Nylon Filling, Quarpel Treated. MIL-C-3924 is one of the military's lightest weight water repellent fabrics and is used in the Snow Camouflage Overwhites and various hood components and caps. The water repellency properties of the fabrics are to be achieved without the benefit of coatings or membranes. Fine and microdenier fiber fabrics were evaluated because they have been marketed as being inherently water repellent and moisture vapor permeable, due to their dense, compact fabric structure, which is accomplished through the use of fine, compact, multifilament yarns and fibers. The fine and microdenier fiber fabrics were obtained from domestic and foreign sources and evaluated for a variety of strength, and water and oil repellency properties. The water and oil repellency performance of the microdenier fabrics was superior to the standard oxford fabric. As fabric weight decreases, the microdenier fiber fabrics fall from good to poor in terms of tensile and tearing strength properties. In addition, the peach skin finish also further decreases the tensile and tearing strength properties. CONT'D

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The fine denier Supplex® fabric was not as water-repellent as the microdenier fiber fabric and fell short on dynamic absorption and filling tearing strength, but meets the desired performance goals for a lighter weight and quick drying fabric.

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PREFACE

The report investigates commercially available fabrics that are lightweight and offer equal or improved water repellency, greater durability, and are quick to dry compared to MIL-C-3924, Cloth, Oxford, Cotton Warp and Nylon Filling, Quarpel Treated. The water repellency properties of the fabrics are to be achieved without the benefit of coatings or membranes. Fine and microdenier fiber fabrics were evaluated because they have been marketed as being inherently water repellent and moisture vapor permeable, due to their dense, compact fabric structure, which is accomplished through the use of fine, compact, multifilament yarns and fibers. The fine and microdenier fiber fabrics were obtained from domestic and foreign sources and evaluated for a variety of strength, and water and oil repellency properties.

This project was undertaken during the period January 1991 to December 1994, and funded under Program Element Number 622786 and Project Number AH98.

EVALUATION OF FINE DENIER AND MICRODENIER MULTIFILAMENT FABRICS

SUMMARY

The Toray and Unitika microfiber fabrics evaluated offer superior water- and oil-repellency properties compared to the standard oxford fabric due to the dense, compact fabric construction resulting from high end and pick counts, low air permeability, the hydrophobic nature of polyester fiber, and a fluorocarbon-type finish. They offer a reduction in weight from 6 to 56 percent over the standard oxford; however, while the fabrics weighing 3.4 ounces per square yard and less meet the water-repellency goals, as the weight decreases they fall from marginal to poor in terms of tensile and tearing strength properties. In addition, the peach skin finish also further decreases the tensile and tearing strength properties. The fine denier Supplex® fabric was not as water repellent as the microdenier fiber fabrics and fell short on dynamic absorption and filling tearing strength but met the desired performance goals for a lighter weight and quick drying fabric.

INTRODUCTION

The objective of this program is to investigate commercially available fabrics that are lightweight and offer equal or improved water repellency, greater durability, and are quick to dry compared to MIL-C-3924, Cloth, Oxford, Cotton Warp and Nylon Filling, Quarpel Treated. MIL-C-3924 is one of the military's lightest weight water-repellent fabrics and is used in the Snow Camouflage Overwhites and various hood components and caps. In this commercial fabric evaluation the water repellency properties of the fabrics are to be achieved without the benefit of coatings or membranes. Fine and microdenier fiber fabrics are of interest because they have been marketed as being inherently water repellent and moisture vapor permeable due to their dense, compact fabric structure, which is accomplished through the use of fine, compact, multifilament yarns and fibers. The microdenier fiber fabrics evaluated were obtained from Japanese suppliers through the Foreign Intelligence Office at U.S. Army Soldier & Biological Chemical Command because they are not readily available in the United States. Japan is considered to be the leader in microdenier technology since researchers there introduced Ultrasuede,® a microdenier fabric, in 1970. A fine denier fiber fabric was obtained domestically and included in this evaluation. While the U.S. military is prohibited from procuring clothing and textiles that are made abroad due to the Berry Amendment, the Japanese fabrics were obtained purely to evaluate the performance of the new microdenier fibers. Should the materials show promise, U.S. companies will be made aware of the military's interest.

The literature describes microdenier fibers as fibers that are less than one denier per filament (dpf). Denier is the measurement of linear density of the fiber based on the weight in grams of 9,000 meters of fiber. In comparison, the nylon staple component of the Temperate Battledress Uniform (BDU) is 2.5 dpf, the Hot Weather and Desert BDU is 1.7 dpf, and silk, one of the finest natural fibers, is 1.2 dpf.

MATERIALS

While the production method of the fibers used in the sample fabrics evaluated is unknown, the literature describes three manufacturing methods for microdenier fibers, which are melt spinning, conjugate spinning, and composite spinning. Melt spinning, which is the only method known to be in domestic use, can be adapted to produce microdenier fibers; however, good uniformity and tight process control are extremely critical in order to produce high quality yarns with acceptable yields.[1, 2] Conjugate spinning, the second method, utilizes more than one polymer to produce each filament in a yarn bundle. Polymers are chosen that are not compatible and do not strongly adhere to each other, and when extruded as one filament, subsequent processing causes the filaments to split into two finer filaments, as illustrated in Figure 1. If the differing polymers were in alternate segments of a conjugate system, the filament would split into as many segments of finer filaments, e.g. a 3 dpf filament comprising 6 segments would split into six 0.5 dpf microfilaments.[1, 2] Composite spinning, the third method, also utilizes a number of different polymers. One polymer can be embedded in another in discrete fine filaments. After spinning, the polymer comprising the continuous phase can be dissolved and extracted leaving the very fine filaments intact, as illustrated in Figure 2. This method has also been referred to as "Islands in a Sea" where one polymer forms the "sea" component and the other(s) forming the "islands." After spinning, the polymer composing the "sea" is dissolved leaving very fine filaments (islands).[1, 2, 3]

FABRIC DESCRIPTION

All of the commercial Japanese fabrics are composed of polyester multifilament yarns. While these fabrics were obtained through the Foreign Intelligence Office, the Japanese manufacturers have sales offices in the U.S.. Additional information or yardage may be obtained from: Toray Industries, 280 Park Avenue, New York, New York 10017, or Unitika American Corporation, 1180 Avenue of the Americas, New York, New York 10036. The Supplex fabric is made from nylon and is produced domestically. According to the manufacturer, Burlington Industries, the Supplex fabric is made from fibers that are slightly greater than 1 dpf, qualifying them as fine denier fibers rather than microdenier fibers. The warp yarn is singles and the filling is three ply and air jet texturized. The Supplex fabric is also treated with a fluorocarbon water and oil repellent treatment. The control fabric, VEE 6320, is composed of spun cotton warp and a nylon multifilament filling and is treated with a fluorocarbon treatment.

The eight fabrics tested, and their manufacturers, are as follows:

a) VEE 6304 - 4.2 ounces per square yard, plain weave, H20FF™ manufactured by Toray Industries.

b) VEE 6305 - 2.1 ounces per square yard, plain weave, Gymstar-EQ™ manufactured by Unitika.

c) VEE 6307 - 3.4 ounces per square yard, plain weave, Gymstar-Plus™ manufactured by Unitika.

d) VEE 6309 - 4.4 ounces per square yard, twill weave, "peach skin" finish, Gymstar-Plus manufactured by Unitika.

e) VEE 6306 - 4.5 ounces per square yard, twill weave, Gymstar-Plus manufactured by Unitika.

f) VEE 6308 - 5.0 ounces per square yard, twill weave, Gymstar-Plus manufactured by Unitika.

g) VEE 6849 – 3.5 ounces per square yard, oxford weave, Supplex manufactured by Burlington Industries.

h) VEE 6320 - 5.0 ounces per square yard, twill weave, manufactured in accordance with MIL-C-3924 Cloth, Oxford, Cotton Warp and Nylon Filling, Quarpel Treated.

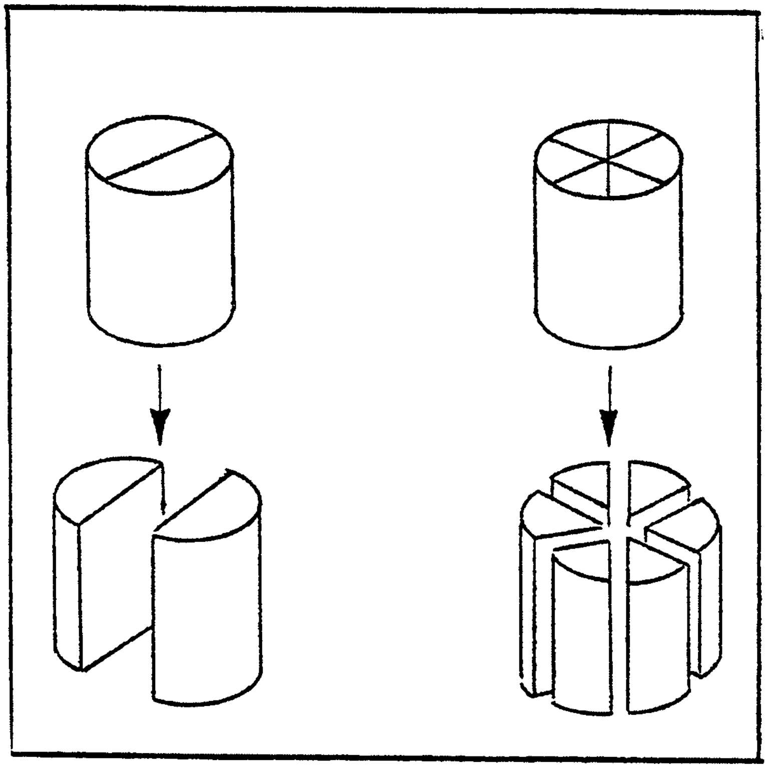

Figure 1. Conjugate Fiber[1]

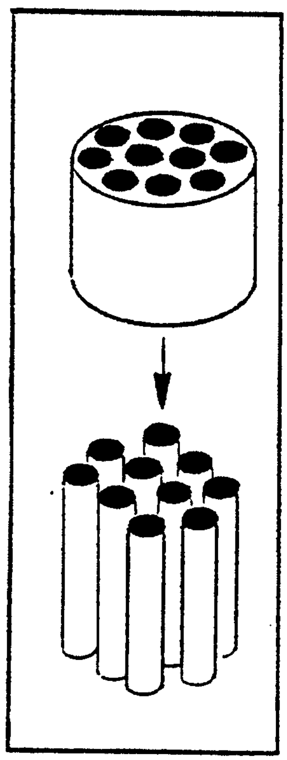

Figure 2. Composite Fiber [1]

TEST METHODOLOGY

The unique characteristic of the Japanese fabrics is that they are reported to be manufactured from microdenier fibers. An analysis using the Scanning Electron Microscope (SEM) was conducted to either confirm or disprove this claim. The yarn number for both the warp and filling of each fabric was measured. Cross-sections of each fabric were prepared and then photomicrographs were taken. The average fiber denier was estimated based on the yarn denier and the number of filaments counted per each yarn cross-section.

All other tests were performed in accordance with either the American Society for Testing and Materials (ASTM) or American Association of Textile Chemists and Colorists (AATCC) methods shown in the Appendix. MIL-C-3924 is used as a guide for performance goals, which are listed in Tables 1-4. In addition, performance data collected from fabric received during the First Article examination of contract number DLA 100-85-C-0482 for MIL-C-3924, Class 3 (Woodland Camouflage Printed) identified as VEE 6320 is listed in Table 1 and 4 for comparison purposes.

RESULTS AND DISCUSSION

1. Toray Fabric. The warp and filling yarns in the Toray fabric, identified as VEE 6304, are composed of two different denier fibers, as illustrated in the SEM photomicrographs, Figures 3 and 4. The average fiber denier is estimated based on the yarn denier and the number of filaments per cross- section. Based on these measurements, the average fiber denier is 0.8 dpf with the finer fibers estimated to be in the microdenier fiber range; however, the coarse fibers appear to exceed one denier per filament. This observation is supported by the company literature, which describes the yarns in this fabric as being composed of 0.4 dpf microdenier fibers and other fine filament fibers (most likely not microfibers).[4]

Table 1. Physical- and Water-Repellency Properties of Toray Fabric

Property	VEE 6304	Standard Oxford VEE 6320	Performance Goal
Weight oz/yd^2	4.2	5.4	4.8 – 5.8
Thickness	0.012	0.011	-
Yarns per inch, Warp x Filling	145 x 84	166 x 79	160 x 74
Yarn Number Warp x Filling	137 x 136 den.	60/2 c.c. x 100 den.	-
Tearing Strength, lbs. Warp x Filling	7 x 3	6 x 6	-
Breaking Strength, lbs. Warp x Filling	265 x 159	166 x 151	140 x 125 (min)
Flexural Rigidity, Warp Filling Overall	 - - -	 110 50 74	 - - -
Abrasion Resistance, Cycles	667	600	-
Air Permeability ft.^{3}/min./ft^2	3	3	3 (max.)
MVTR, g/m^2/24 hrs.	943	947	-
Spray Rating	100, 100, 100	90, 90, 90	90, 90, 80 (min)
Hydrostatic Height, cm Initial After 3 launderings	 55 62	 42 40	 30 (min avg.) 20 (min avg.)
Dynamic Absorption, % Initial After 15 launderings	 0 0	 13 13	 20 (max. avg) 20 (max. avg)
Resistance to Organic Liquid Initial After 15 launderings	 Pass Pass	 Pass Pass	 No wetting* No wetting*
Dimensional Stability, % Warp x Filling	0.4 x 0.1	0.7 x 0.9	2.0 (max)

*No wetting n-tetradecane.

Table 2. Physical- and Water-Repellency Properties of Unitika Fabrics

Property	**VEE 6305**	**VEE 6306**	**VEE 6309**	**Performance Goal**
Weight oz/yd^2	2.1	4.5	4.4	4.8 – 5.8
Yarns per inch, Warp x Filling	169x111	146 x 95	139 x 94	160 x 74 (min)
Yarn Number Denier	-	122 x124	-	-
Tearing Strength, lbs. Warp x Filling	2 x 2	8 x 4	4 x 4	-
Breaking Strength, lbs. Warp x Filling	130 x 98	306 x 130	159 x 116	140 x 125 (min)
Air Permeability ft.^{3}/min./ft^2	2	1	7	3 (max)
MVTR, g/m^2/24 hrs.	926	938	971	-
Spray Rating	100, 100, 100	100, 100, 100	100, 100, 100	90, 90, 80
Hydrostatic Height, cm Initial After 3 launderings	 47 36	 62 46	 32 48	 30 (min avg) 35 (min avg)
Dynamic Absorption, % Initial After 15 launderings	 1 2	 2 0	 6 0	 20 (max) 20 (max)
Resistance to Organic Liquid Initial After 15 launderings	 - -	 Pass Pass	 - -	 No wetting* No wetting*

*No wetting n-tetradecane.

Table 3. Physical Properties of Unitika Fabrics

Property	VEE 6307	VEE 6308	Performance Goal
Weight oz/yd^2	3.4	5.0	4.8 – 5.8
Yarns per inch, Warp x Filling	143 x 72	142 x 97	-
Tearing Strength, lbs. Warp x Filling	5 x 3	8 x 5	-
Breaking Strength, lbs. Warp x Filling	217 x 123	363 x 217	140 x 125 (min)
Air Permeability, ft.^{3}/min./ft^2	1	2	3 (max)
Flexural Rigidity, Warp Filling Overall	 - - -	 50 50 50	 - - -

Table 4. Physical- and Water-Repellency Properties of Supplex Fabric

Property	VEE 6849	VEE 6320	Performance Goal
Weight oz/yd^2	3.7	5.4	4.8-5.8
Yarns per inch, Warp x Filling	152 x 64	166 x 79	160 x 74 (min)
Tearing Strength, lbs. Warp x Filling	6 x 4	6 x 6	-
Breaking Strength, lbs. Warp x Filling	246 x 199	166 x 151	140 x 125 (min)
Air Permeability, ft.^{3}/min./ft^2	11	3	3 (max)
Spray Rating	100, 100, 100	90, 90, 90	90, 90, 80
Hydrostatic Height, cm Initial After 3 launderings	 35 38	 42 40	 30 (min avg) 35 (min avg)
Dynamic Absorption, % Initial After 15 launderings	 25 28	 13 13	 20 (max) 20 (max)
Resistance to Organic Liquid Initial After 15 launderings	 Pass Pass	 Pass Pass	 No wetting* No wetting*

*No wetting n-tetradecane.

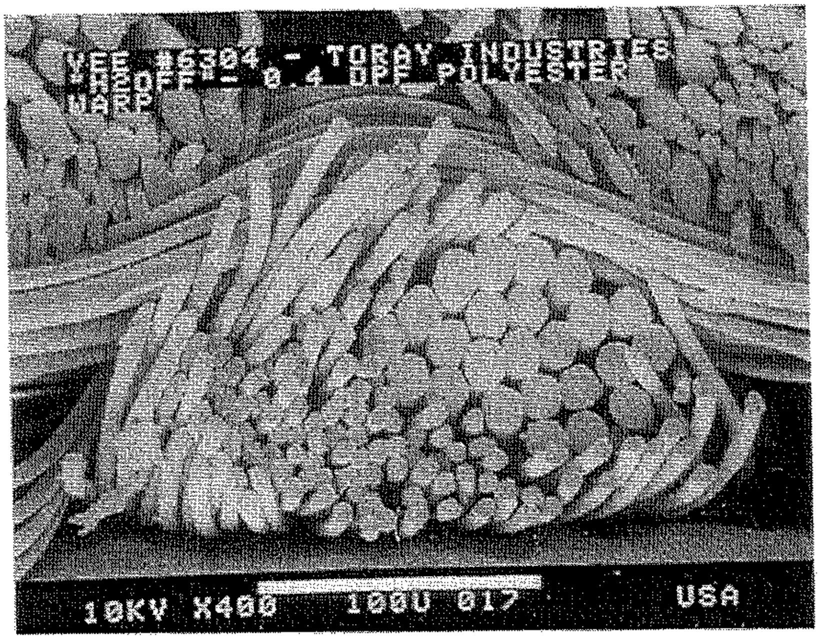

Figure 3. Toray Warp Yarn, Cross-Section

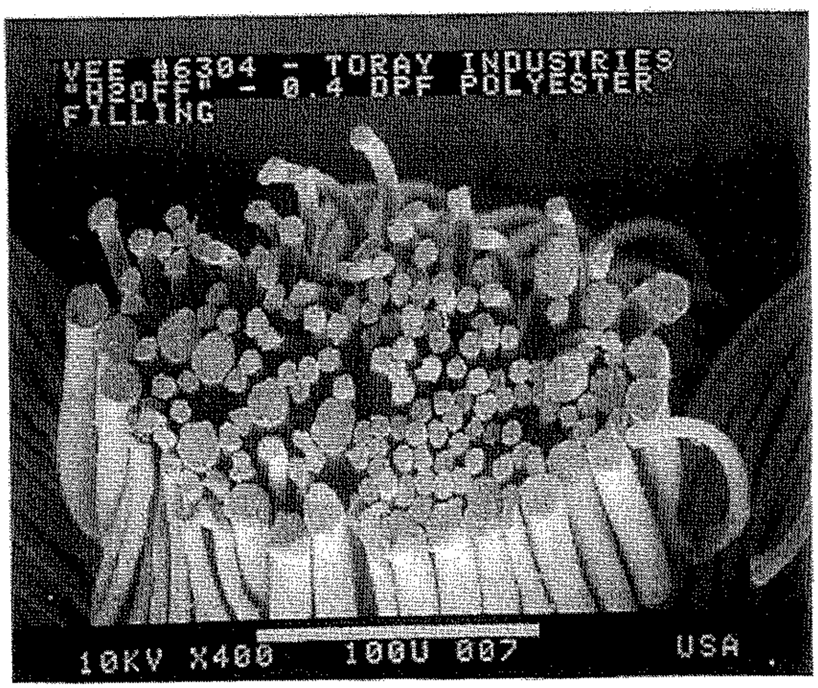

Figure 4. Toray Filling Yarn, Cross-Section

The physical- and water-repellency characteristics of the Toray fabric and the standard oxford fabric are listed in Table 1. Both the standard oxford and Toray fabrics have low air permeability and high end and pick counts resulting in dense, tight fabric constructions as illustrated in the SEM photomicrographs, Figures 5 and 6. The dense fabric constructions contribute to the water-repellency properties of both fabrics that meet all performance goals for water repellency. The Toray fabric exhibits superior water-repellency properties compared to those typical of the standard oxford. The 62 centimeter hydrostatic height (after 3 launderings) and 0 percent dynamic absorption (after 15 launderings) are considered to be unusually good for a non-coated woven fabric, and the moisture vapor transmission rate (MVTR) is comparable to the standard oxford. In addition, the Toray fabric is resistant to 7 organic liquids as described in AATCC Test Method 118 indicating that it is treated with a fluorocarbon-type oil repellent finish. The fabric also showed no wetting after 3 launderings by bis (2 ethyl hexyl) hydrogen phosphite, tri-ethyl phosphate, and di-methyl phosphonate after 8 hours.

The Toray fabric is 22 percent lighter in weight than the oxford fabric, but similar in thickness and abrasion resistance. The Toray fabric is almost 60 percent greater in the warp breaking strength than the standard oxford fabric. Generally, the higher the number of warp yarns the greater the breaking strength, and in this case the standard oxford has more ends. However, the Toray fabric is composed of filament yarns in both the warp and filling direction, and filament yarns are stronger than spun yarns of equal size. The filling strength of the Toray fabric is slightly greater than the standard oxford, which has filament filling yarns, but the Toray fabric has more filling yarns per inch and each yarn is composed of many more filaments.

The Toray fabric has 7 x 3 pound (warp x filling) tearing strengths versus 6 x 6 pounds for the standard oxford. In general, fabrics with tight, dense constructions have lower tearing strength than loose, open fabrics because the yarns in open constructions have more room to group together and share the tearing load. While both fabrics have dense constructions the low filling treating strength of the Toray fabric may be attribute to its reduced weight.

The Toray fabric, which is composed of microdenier fibers and other filament fibers and treated with a fluorocarbon type water and oil repellent finish, meets all of the performance goals tested of the standard oxford fabric, with the exception of filling tearing strength. The fabric has excellent water and oil repellency properties and moisture vapor transmission rate. While there is no known standardized test to measure drying time, it is expected that the fabric will be quick drying due to the fact that it is made completely of hydrophobic fiber and has a dynamic absorption value of zero. It is 22 percent lower in weight, 60 percent greater in warp breaking strength, and similar in abrasion resistance compared to the oxford fabric (VEE 6320), but is 50 percent lower in filling tearing strength.

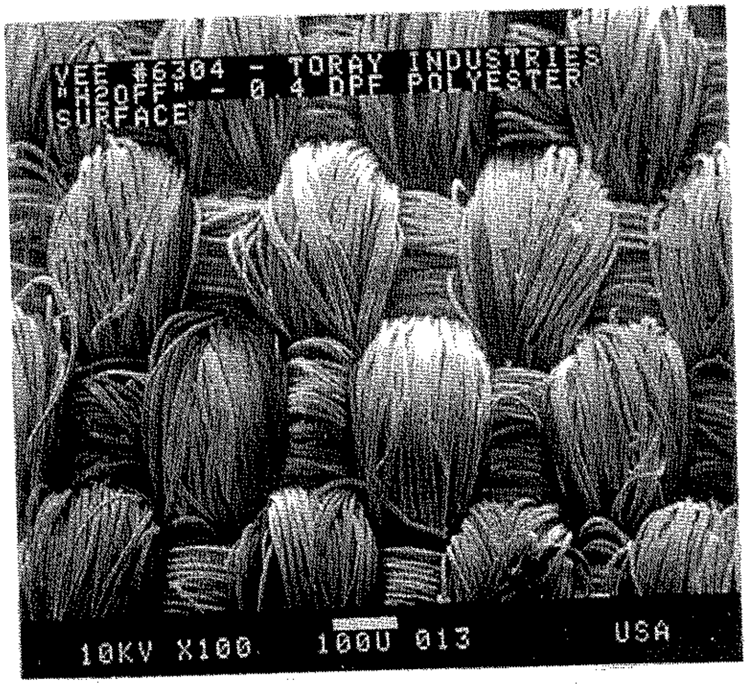

Figure 5. Toray Fabric Structure

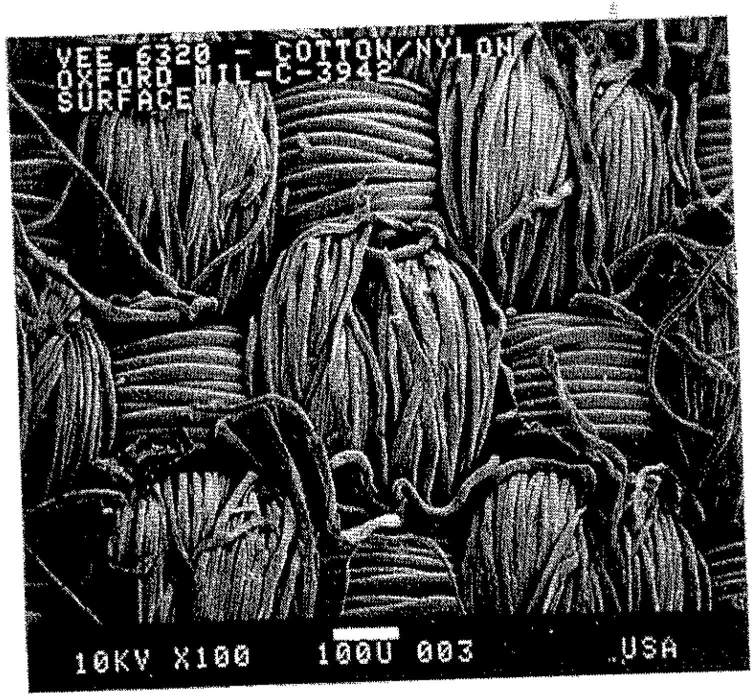

Figure 6. MIL-C-3924 Fabric Structure

2. Unitika Fabrics. The warp and filling yarns of the Unitika fabric identified as VEE 6306, are also composed of various size denier fibers, as illustrated in the SEM photomicrographs, Figures 7 and 8. Based on the measurements described above the average fiber denier is estimated to be 0.6 dpf. The literature describes the yarns as being composed of 0.5 dpf polyester fiber.[4] The dense fabric construction is also illustrated in the SEM photomicrograph, Figure 9. The five Unitika fabrics evaluated range in weight from 2.1 to 5.0 ounces per square yard and all have low air permeability and high end and pick counts, as listed in Tables 2 and 3.

VEE 6306 and 6308, which have the highest weights of the Unitika fabrics, 4.5 and 5.0 ounces per square yard respectively, exhibited the best physical properties of all the Unitika fabrics. VEE 6306 is 17 percent lower in weight and is 84 percent greater in warp breaking strength compared to the standard oxford, however, the filling tearing strength of 4 pounds is marginal. The 46 cm hydrostatic height (after 3 launderings) of VEE 6306 is good, as well as the 0 percent dynamic absorption (after 15 launderings), and the MVTR is comparable to the standard oxford. VEE 6306 exhibited low dynamic absorption values, as did the Toray fabric, and this property is attributed to the hydrophobic nature of the polyester fiber. In addition, VEE 6306 is resistant to 7 organic liquids as described in AATCC Test Method 118 indicating that it also is treated with a fluorocarbon type oil repellent finish. The fabric also showed no wetting after 3 launderings by tri-ethyl phosphate, di-methyl phosphonate and bis (2 ethly hexyl) hydrogen phosphite after 8 hours.

VEE 6305 had the lowest weight and highest end and pick count, but exhibited the lowest tearing strength of 2 x 2 pounds and the lowest breaking strength of 130 x 98 pounds of all the Unitika fabrics. While this fabric meets the water repellency requirements of the standard oxford, it would not be expected to provide the durability and wear life of the standard oxford.

VEE 6306 and 6309 are similar in weight, end and pick count, and weave, but VEE 6309 exhibits a 48 x 11 percent reduction in warp and filling breaking strength respectively and a 50 percent reduction in warp tearing strength compared to VEE 6306. The decrease in tensile and tearing strength is attributed to the peach skin finish of VEE 6309. The peach skin effect is accomplished by an emerizing (sanding) process, which is know to reduce the tensile properties of the fabric if the process is not carefully controlled.[5]

Microdenier fiber fabrics are marketed as being more flexible due to the increased number of filaments per yarn cross section, however, for the same fabric weight, the flexural rigidity in the filling direction of VEE 6308 is the same as that of the standard oxford. The filament yarn size of the filling in the oxford fabric is 100 denier, and is made of 3.0 dpf. The flexural rigidity in the warp direction of the oxford is greater than that of VEE 6308 because the standard oxford has spun warp yarns. The greater stiffness of the warp yarns gives the standard oxford a greater overall flexural rigidity compared to VEE 6308.

The Unitika fabric identified as VEE 6306 is composed of microdenier fibers and treated with fluorocarbon type water and oil repellent treatment meets all of the performance goals tested of the standard oxford fabric, with the exception of filling tearing strength. The fabric has excellent water and oil repellency properties and moisture vapor transmission rate. While there is no known standardized test to measure drying time, it is expected that the fabric will be quick drying due to the fact that it is made completely of hydrophobic fiber and has a dynamic absorption value of zero, after laundering. It is 17 percent lower in weight, 84 percent greater in warp breaking strength compared to typical oxford fabrics (VEE 6320), but it is 33 percent lower in filling tearing strength.

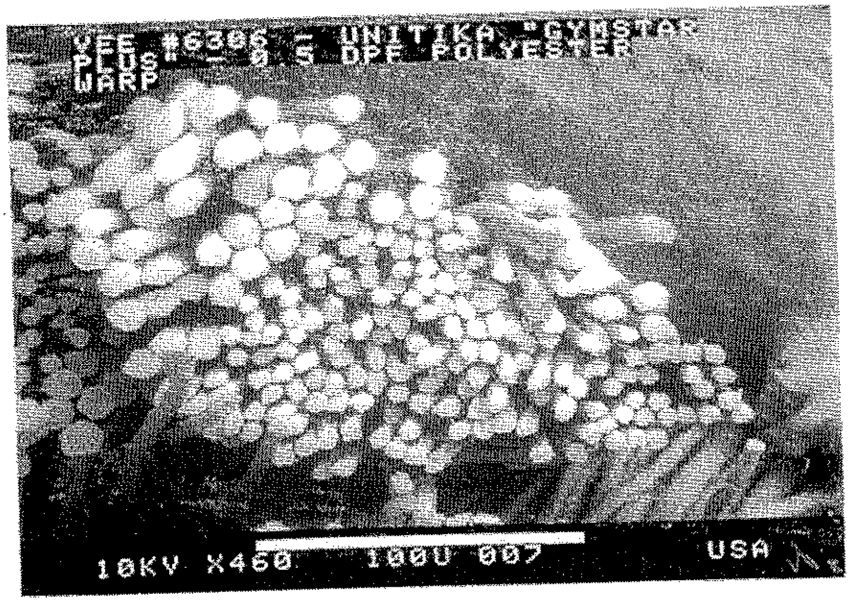

Figure 7. Unitika Warp Yarn, Cross-Section

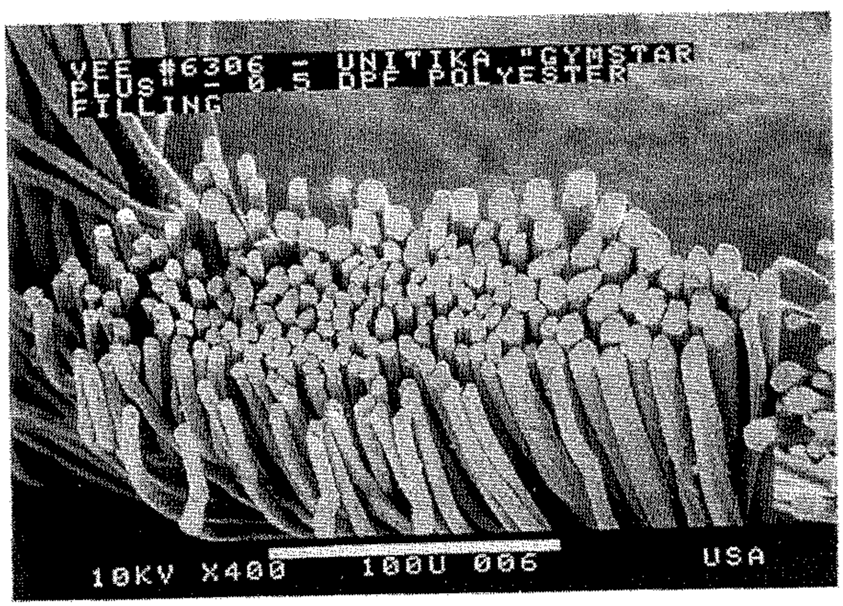

Figure 8. Unitika Filling Yarn, Cross-Section

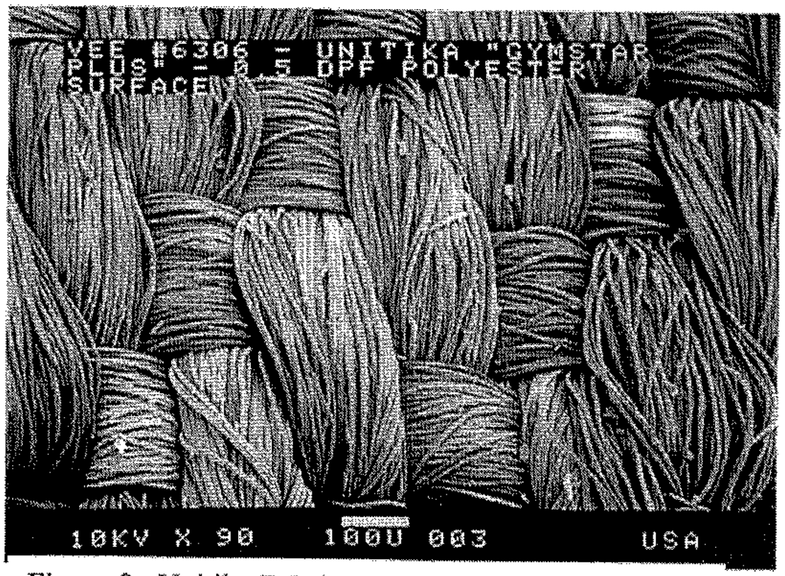

Figure 9. Unitika Fabric Structure Surface

3. Supplex Fabric. The physical and water repellency characteristics of the Supplex fabric and the standard oxford are listed in Table 4. The Supplex fabric, which is made from fine rather than microdenier fibers, has a relatively high end count, but the lowest pick count of all the fabrics evaluated. It also has the highest air permeability. This indicates that the fabric is slightly more open than all the other fabrics and as expected does not have the same high level of water repellency as the other fabrics. While there is no known standardized test to measure drying time, it is expected that the fabric will be quick drying due to the fact that it is made completely of hydrophobic fiber. It did not meet the end and pick requirements, and exceeded the air permeability and dynamic absorption requirements for the standard oxford fabric. In addition, the Supplex fabric is 31 percent lighter in weight, 48 percent greater in warp breaking strength, but is 33 percent lower in filling tearing strength than the standard oxford fabric.

CONCLUSIONS

The Toray and Unitika microfiber fabrics evaluated offer superior water and oil repellency properties compared to the standard oxford fabric due to the dense, compact fabric construction resulting from high end and pick counts, low air permeability, hydrophobic nature of polyester fiber, and fluorocarbon type finish. They offer a reduction in weight from 6 to 56 percent over the standard oxford; however, while the fabrics weighing 3.4 ounces per square yard and less meet the water repellency goals, as the weight decreases they fall from marginal to poor in terms of tensile and tearing strength properties. In addition, the peach skin finish further decreases the tensile and tearing strength properties. The fine denier Supplex fabric was not as water repellent as the microdenier fiber fabrics but met many of the desired performance goals.

In regards to the program requirements for a fabric that is lighter in weight, more durable, demonstrates greater water repellency and is quick drying, the Toray fabric, the Unitika fabric identified as VEE 6306, and the Supplex fabric all demonstrate generally acceptable performance in light of some trade offs. The Toray fabric and the Unitika fabric demonstrate superior water repellency characteristics, but fall short on filling tearing strength. The Supplex fabric fell short on dynamic absorption and filling tearing strength but met the desired performance goals for a lighter weight and quick drying fabric.

RECOMMENDATIONS FOR FUTURE WORK

Evaluate the Toray and Unitika fabric for chemical protection applications. The superior water and oil repellency properties and lighter weight appear to make these fabrics ideal candidates for chemical protection. While the tensile and tearing strength properties decrease as the weight decreases, the durability may not be critical due to the short wear life of the chemical protective garment.

This document reports research undertaken at the U.S. Army Soldier and Biological Chemical Command, Soldier Systems Center, Natick, MA, and has been assigned No. NATICK/TR-02/008 in a series of reports approved for publication.

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APPENDIX

Test Methods

AATCC Method No.	Title
AATCC-42	Water Repellency: Spray Test
AATCC-70	Water Repellency; Tumble Jar Dynamic Absorption Test
AATCC-96 Test VI, A	Dimensional Changes in Commercial Laundering of Woven and Knitted Fabrics Except Wool
AATCC-96 TestVc, D	Dimensional Changes in Commercial Laundering of Woven and Knitted Fabrics Except Wool
AATCC-118	Oil Repellency; Hydrocarbon Resistance Test
AATCC-127	Water Resistance; Hydrostatic Pressure Test

ASTM Method No.	Title
ASTM E 96	Water Vapor Transmission of Materials, Procedure B
ASTM-D-737	Air Permeability of Textile Fabrics
ASTM-D-1388	Stiffness of Fabrics – Option A
ASTM D 1424	Tear Resistance of Woven Fabrics by Falling Pendulum (Elmendorf) Apparatus
ASTM-D-1777	Thickness of Textile Materials
ASTM-D-3775	Fabric Count of Woven Fabric
ASTM-D-3776	Mass Per Unit Area (Weight) of Fabric Option C
ASTM-D-3884	Abrasion Resistance of Textile Fabrics (Rotary Platform, Double-Head Method)
ASTM-D-5034	Breaking Force and Elongation of Textile Fabrics (Grab Test), G-E or G-T